TEMPERATURE REGULATION AS A TOOL FOR ENABLING AND PROGRAMMING SYNTHETIC MICROBIAL COMMUNITIES

Adam Krieger, Cellular and Molecular Biology Program, University of Michigan, USA
agkrieg@umich.edu
Jiahao “Jeff” Zhang, Chemical Engineering Department, University of Michigan, USA
Xiaoxia “Nina” Lin, Chemical Engineering Department, University of Michigan, USA

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As target applications grow more elaborate, researchers are developing new approaches to program increasingly complex functionality into synthetic biology platforms. One emerging approach is engineering cooperative, multi-species synthetic microbial communities, which offer significant potential advantages compared to single species systems for numerous applications such as biosynthesis of target compounds through complex pathways enabled by division of labor. However, population dynamics, inter-species interactions, and differing ecological niches of resident microorganisms also introduce complexities that must be addressed to achieve effective and robust synthetic microbial communities. One fundamental challenge is regulation of community composition. At the most basic level, maintaining coexistence of resident community members is required to enable the desired community level functionality. Additionally, community composition often needs to be tuned to optimize overall functionality. For example, when a complex pathway is divided into multiple components hosted by different community members, fluxes through different enzymatic reactions can be coordinated through modulation of each sub-population size to maximize overall efficiency. This type of microbial community manipulation has not been fully utilized in synthetic biology applications, likely due in part to limited available tools. Here we develop temperature regulation as a general tool to enable coexistence and control community composition in synthetic microbial communities. We demonstrate that rationally selected constant temperature regimes can be used to enable coexistence of species from distinct thermal niches. Furthermore, cycling temperature regimes can be used to regulate relative species abundance in microbial communities. We employ mathematical modeling to design cycling temperature regimes for desired community compositions and related features. As microbial communities are increasingly used in a variety of applications, we envision that tools for modulating community composition will continue to expand and we see temperature regulation as a powerful new approach in this area.